Associations of commuting to school and work with demographic variables and with weight status in eight European countries: the ENERGY-cross sectional study

Saskia J te Velde[1,8] (saskia@tevelderesearch.com)

Eli Haraldsen[1] (eli.haraldsen@gmail.com)

Frøydis N. Vik[1] (froydis.n.vik@uia.no)

Ilse De Bourdeaudhuij[2] (Ilse.Debourdeaudhuij@UGent.be)

Natasa Jan[3] (drustvo-zasrce@siol.net)

Eva Kovacs[4] (e.k.kovacs@gmail.com)

Luis A. Moreno[5] (lmoreno@unizar.es)

Alain Dössegger[6] (Alain.Doessegger@baspo.admin.ch)

Yannis Manios[7] (Manios.energy@hua.gr)

Johannes Brug[8] (j.brug@uva.nl)

Elling Bere[1*] (elling.bere@uia.no)

[1] Department of Public Health, Sport and Nutrition, University of Agder, Norway

[2] Department of Movement and Sport Sciences, Ghent University, Ghent, Belgium

[3] Slovenian Heart Foundation, Ljubljana, Slovenia

[4] Department of Pediatrics, Pecs University, Pecs, Hungary

[5] GENUD (Growth, Exercise, Nutrition and Development) research group Facultad de Ciencias de la Salud, Universidad de Zaragoza, Zaragoza, Spain

[6] Federal Office of Sport, Magglingen, Switzerland

[7] Department of Nutrition and Dietetics, Harokopio University, Athens, Greece

[8] EMGO Institute for Health and Care Research and the department of Epidemiology

and Biostatistics, VU University Medical Center, Amsterdam, the Netherlands

* Corresponding author: Elling Bere (elling.bere@uia.no)

Address: University of Agder, Postboks 422, N-4604 KRISTIANSAND, NORWAY

Telephone: + 47 38141883

Key words: children, parents, weight status, active commuting, cycling

Word count abstract: 221

Word count main text: 4361

This study aims to assess the prevalence of different modes of commuting to school and work for 10-12 year-olds and their parents; to assess the associations with demographic variables(country, sex, parental education and ethnicity) and with weight status in eight European countries.

As part of the ENERGY project a cross-sectional survey was conducted in 2010 in which modes of commuting and socio-demographic variables for children (N= 7903) and one of their parents (n= 6455) were measured by questionnaires. Children's weight and height were objectively measured; parents self-reported their weight and height. Logistic multilevel regression analyses assessed the associations between mode of commuting and overweight. Differences between countries and differences in mode of commuting according to demographic variables were tested using $\chi2$-test and Marascuilo's Post-hoc analysis.

There were marked differences between countries, especially regarding cycling to school, which was common in the Netherlands and Norway and rare in Greece and Spain. Demographic variables were associated with mode of commuting in children and parents. Mode of commuting was not associated with being overweight in children, after adjustment for demographic variables. Bicycling to work, but not other modes of commuting, was significantly inversely associated with being overweight among parents (OR=0.74 (95%CI 0.57-0.97)).

Interventions targeting active commuting may promote cycling, and should take into account the differences regarding demographic variables.

Highlights

- Mode of commuting to school was not associated with weight status among children
- Cycling to work was inversely associated with weight status among parents of 10-12 year old children
- Mode of commuting varies by country, sex, ethnicity and parental education among children and parents

Introduction

Active commuting, such as walking and cycling to school or work has the potential to increase physical activity, contribute to energy balance and physical fitness and ultimately prevent non-communicable diseases (Andersen, Lawlor, Cooper, Froberg, & Anderssen, 2009; Audrey, Procter, & Cooper, 2014; Chaix et al., 2014; Larouche, Saunders, Faulkner, Colley, & Tremblay, 2014; Taddei et al., 2015). It may also help to prevent overweight among adults, and probably also among children (Bere, Seiler, Eikemo, Oenema, & Brug, 2011; Bopp, Kaczynski, & Campbell, 2013; Faulkner, Buliung, Flora, & Fusco, 2009; Flint, Cummins, & Sacker, 2014; Larouche et al., 2014; Lee, Orenstein, & Richardson, 2008). In addition, the health effects of active commuting might be different for walking or cycling (Andersen, Schnohr, Schroll, & Hein, 2000; Bopp et al., 2013; Larouche et al., 2014; Ostergaard, Kolle, Steene-Johannessen, Anderssen, & Andersen, 2013). Larouche and colleagues concluded in their review that there is moderate evidence that cardiovascular fitness is better in children who cycle to school compared to passive travellers, while the evidence for this is inconclusive for those walking to school (Larouche et al., 2014). The intensity achieved when walking appears to be adequate for older adults in order to gain cardio-respiratory benefits (Shephard, 2008). For children and young adults with higher fitness, cycling may provide a sufficient intensity level to achieve health benefits, such as reduced mortality and reduced risks for overweight (Bopp et al., 2013; Lindstrom, 2008; Wen & Rissel, 2008). Some studies found similar results among children, and have indicated a healthier body weight when cycling to school as compared to walking or passive transport (Andegiorgish, Wang, Zhang, Liu, & Zhu, 2012; Andersen et al., 2009; Cooper et al., 2008; Ostergaard, Borrestad, Tarp, & Andersen, 2012). However, only a few studies actually differentiated mode of commuting (Andegiorgish et al., 2012; Cooper, Andersen, Wedderkopp, Page, & Froberg, 2005; Cooper et al., 2006; Cooper et al., 2008; Duncan et al., 2011; Voss & Sandercock, 2010) and those who combined walking and cycling found inconsistent results (Bere & Andersen, 2009; Larouche et al., 2014; Lee et al., 2008). These inconsistent findings might be explained by the fact that most studies (see (Lee et al., 2008)) had combined walking and cycling to school (Bere & Andersen, 2009). Further explanations can be found in the different methods used to assess active commuting and the fact that most studies were conducted among populations with very low frequencies of children cycling to school. Moreover, it may take more time to reach health benefits from active commuting and children are not yet exposed long enough to already detect health effects (Martinez-Gomez et al., 2014).

Socio-demographic factors –such as ethnicity, gender and socio-economic status (SES) have been found to be associated with children's and adults' commuting behaviour, but with mixed results (Babey, Hastert, Huang, & Brown, 2009; Davison, Werder, & Lawson, 2008; Pucher & Buehler, 2008) For example, non-native children seem to use active modes of commuting more often (Evenson, Huston, McMillen, Bors, & Ward, 2003), but in countries where cycling is prominent like the Netherlands, children and adolescents of native ethnicity are more likely to cycle to school (Bere, van der Horst, Oenema, Prins, & Brug, 2008). Higher SES groups may be more likely to commute by bicycle (Bere et al., 2008; Borrestad, Andersen, & Bere, 2011; Timperio et al., 2006), while in certain European countries (The Netherlands, Switzerland and Germany), low income adults more often use active commuting (Pucher & Buehler, 2008). The ENERGY-project includes countries that differ in cycling and walking habits and has data about socio-demographic variables, it therefore provides the opportunity to study whether the observed inconsistencies in the literature, can be explained by country differences. Previous publications on the ENERGY-project already reported about the average number of days that children cycled or walked to school, how this varied by country (Brug, van Stralen, Te Velde et al., 2012) and ethnicity (Brug, van Stralen, Chinapaw et al., 2012), but did not report on the associations with overweight. Nor did the previous publications report on modes of commuting among parents.

Hence, the current study will explore if and how mode of commuting varies by country, sex, parental education and ethnicity among schoolchildren and their parents. In line with previous findings, we hypothesize that those with non-native background will more often use active modes of transportation, except in the Norway and The Netherlands, where cycling is so common among children of native ethnicity. Furthermore, that those with higher parental education will more often use active modes and that there will be large differences in most often used modes of transportation between countries.

For overweight prevention and weight management, and acknowledging the fact that overweight in youth tracks into adulthood (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008), active commuting might be an important and effective structural solution to contribute to curbing the prevalence of overweight, and for enhancing physical activity in daily life for both children and adults. In the ENERGY-project (Brug et al., 2010) data of different modes of commuting to school (children) and to work (parents), and data on overweight status were collected. It therefore provides a unique opportunity to study the prevalence of different modes of commuting to school or work and to assess their associations with weight status in eight European countries. This may provide new insights in how specific modes are associated with overweight and whether potential differences can be explained by country differences. We hypothesize that cycling will be inversely associated with overweight, while the other modes will not be associated with overweight. As the current study concerns both child and adult data, we will compare the strength of the potential associations which may indicate a support or rejection of the hypothesis that long term exposure may be needed to find health effects. We therefore expect that this association is stronger in parents than in children.

Methods

This present study used data from the ENERGY-project (European Energy balance Research to prevent excessive weight Gain among Youth)(Brug et al., 2010). The ENERGY-project is a cross-sectional study in eight European countries to assess potential personal, family and school environmental correlates related to energy balance-related behaviours among 10-12 year-old schoolchildren and their parents. Ethical approval was obtained from Medical Ethical review committees in all participating countries (Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia, Spain and Switzerland).

Procedure and sample

Seven countries from the ENERGY consortium, Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain participated in the cross-sectional survey in March – July of 2010. An eighth country, Switzerland, joined in a later phase, June –

December of 2010 (Herzig et al., 2012). Each country was represented by a local research institute, with each partner being responsible for the data collection in their country. The standardized procedure for sampling, data collection, and data handling for the survey was the same in all countries (van Stralen et al., 2011).

The cross-sectional survey was carried out in primary schools among 10-12 year-old children. The recruitment and data collection took place from March-July 2010 (Belgium, Greece, Hungary, the Netherlands, Norway, Slovenia and Spain) and between June and December 2010 (Switzerland). Sampling was nationally representative in Greece, Hungary, the Netherlands, and Slovenia. In Spain, schools in the region of Aragón were selected, Belgium selected schools from Flanders (i.e. the northern Dutch-speaking part of Belgium), Norway selected schools from the southern regions of the country and in Switzerland children from the German-speaking part of Switzerland were included (Herzig et al., 2012). Recruitment methods and response rates are described in more detail elsewhere (van Stralen et al., 2011). Briefly, between 15 (Slovenia) and 37 (Greece) schools participated, with a wide range in response rates at the school level (5% in the Netherlands – 100% in Slovenia). Response rates at the child level were in general high (>80%), but in Hungary (33%), Norway (45%) and Spain (43%) lower response rates were obtained, mainly because of parents not returning completed parental consent forms.
Children completed the child questionnaire during one school hour in the presence of a research assistant or project worker who guided the completion of the questionnaire according to a standardized protocol. The children brought home parental questionnaire to be completed by one of the parents. In total, 7903 children completed the questionnaires. The response rate among parents was lower. For the current study data from the parent questionnaire was available for 6417 parents of whom 82.2% mothers and with a mean age of 41.4 years. Questionnaires completed by other caregivers (e.g. grandparents, other adults, n=38) were omitted from the current study. Anthropometrics of the children such as height, weight and waist circumference (WC) were taken by trained staff. Descriptive data of the study sample are presented in Table 1.

Measures

Modes of commuting

Active commuting to school/work for both children and parents was assessed by four questions: how many days a week do you usually bicycle/walk/go by car/go by public transport to school/work? Response categories were never, 1 day/week, 2 days/week, 3 days/week, 4 days/week, 5 days/week. Due to the non-normal distribution of the commuting variables, the variables were dichotomized to distinct modes normally used (i.e. at least 4 days per week) from modes that are only occasionally used (e.g. once a week or less). Using the specific mode for less than 4 days a week was coded as '0' and using that mode for at least 4 days a week was coded as '1'. This dichotomized variable was used in the analyses. However, for additional insights and sensitivity analyses the variables were categorized to distinguish modes never used (0 days per week, coded 0), sometimes used (1-3 days per week, coded 1) and usually used (≥ 4 days per week, coded 2)

Overweight status

Children's body height and weight were measured by trained research assistants. Children were measured in light clothing without shoes. Body height was measured with a SECA Leicester Portable stadiometer (to the nearest 0.1 cm). Weight was measured with a calibrated electronic scale SECA 861 (SECA, Germany) (to the nearest 0.1 kg), and WC with a SECA 201 measuring band (to the nearest 0.1 cm). Two readings of each measurement were obtained. A third measurement was taken if the two readings differed more than 1%. Body mass index (BMI) [calculated as body weight (kg) divided by the height (m) squared (kg/m2)]. BMI was calculated for each child; weight status (normal weight, overweight, obesity) was based on the International Obesity Task Force criteria (Cole, Bellizzi, Flegal, & Dietz, 2000). For descriptive purposes only (see Table 1) three categories were distinguished: normal weight (including underweight), overweight and obesity. For the analyses, a dichotomized variable was created in order to separate children with normal weight (including underweight) (coded 0) and overweight (including obesity) (coded 1). Parents self-reported their weight and height and their body weight status was categorized into normal weight (including underweight) (coded 0) and overweight (including obesity) (coded 1), based on WHO`s BMI criteria. BMI ≤ 25 is considered normal weight and BMI 25 - 30 is considered overweight and BMI > 30 is considered as obese (WHO & FAO, 2003).

Demographics

Parental educational level was assessed in the parental questionnaire by one question asking how many years of education both parents had. In line with previous publications about the ENERGY-project (Brug et al., 2012), educational level was dichotomized as follows: if both parents had less than 14 years of education, parental educational level was determined as low (coded 0), and if at least one parent had more than 14 years of education, parental educational level was categorized as high (coded 1).

Ethnicity was operationalized as a distinction between children of immigrant origin (non-native) and of native origin in the country of administration based on the primary language spoken at home which was assessed in the child questionnaire (Brug et al., 2012). The answering categories were tailored to the different countries, including the official language or languages of the specific country or region, the native languages of the largest ethnic minorities, and a category ‘other’. A dichotomous variable was created distinguishing children for whom the official language of the country of administration was the main language spoken at home (native) from those for whom another language was the main language at home (non-native).

As previously reported, test-retest reliability of the transport measures was excellent both for the child (ICC- 0.88-0.94) (39), and parental questionnaire (ICC- 0.91-0.95) (Singh et al., 2012).

Statistics

Analyses were performed using SPSS version 23 and STATA (version 14) for the multilevel analyses. Descriptive analyses were performed to present the prevalence of overweight and commuting to school/work by country.

Binary multilevel logistic regression analyses were performed separately for children and parents, to assess the associations between each mode of commuting and overweight, including obesity, while taking into account the nested design (i.e. children nested within schools). Children attending the same school may be more similar to each other than to children from other schools, e.g. school policy or neighbourhood may influence the use of active forms of transportation. Therefore, children from the same school will resemble each other regarding active transport, in other words, the observations are not independent. When not taking this into account, the standard errors of the regression coefficients will be underestimated.

Due to very low prevalence rates for specific modes of commuting in some countries (see Tables 2 & 3), adjusted logistic regression analyses with country as an independent variable and mode of commuting as the dependent variable was not possible. Therefore, unadjusted comparisons of the prevalence rates between the countries were made by Marascuilo's Post-hoc analyses for which the assumptions were met (Statistical toolkit (StatsToDo). 2014). Unadjusted comparisons of mode of commuting by sex, weight status, ethnicity and educational level were performed by χ^2-test.

Results are presented as numbers, proportions and/or odds ratios (OR) and their 95% confidence intervals (95%CI).

Results

Children's mode of commuting to school

In the total sample, 21.1% of the children cycled on at least four days/week to school, 49.2% most often walked, while 19.7% and 9.2% respectively went to school most often by car or public transport (Table 2). Notably, additional analyses presented in the supplementary file (Table I) shows that 67.5% reported to never cycle to school, while 35.9% reported to never walk to school.

Demographics and commuting to school

Overall associations between usual mode of transportation and demographic variables are shown in Table 2 and more detailed results can be find in Table I in the Supplementary file. Table 2 further shows that a higher proportion of boys than girls cycled at least four days per week, while the opposite was found for walking to school.

Children from lower educated parents less often cycled or were brought by car on four days per week, but more often walked or went by public transport on four days per week compared to children from higher educated parents (Table 2). Table I in the supplementary file shows that they also more often reported to never cycle to school or to never been brought by car than children from higher educated parents.

Non-native children more often walked but less often were brought by car to school on at least four days per week than native children.

The most often used mode of commuting to school varied by country (Table 2); with The Netherlands and Norway showing the highest rates of frequent cycling to school, while Greece and Spain showing the highest rates of frequent walking to school. Belgium showed the highest proportion of children being brought by car on at least four days a week, while this was lowest, and very rare in Switzerland. Taking public transport to school was most common in Hungary, and most uncommon in The Netherlands and Spain.

Overweight and commuting to school

Table 2 shows that a higher proportion of normal weight than overweight children cycled on at least four days to school. The contrary was found for walking to school. These associations of weight status with cycling and walking are confirmed in the crude multilevel logistic regression analyses, that show an inverse association between cycling and overweight, and a positive association between walking and overweight. However, after adjusting for country and sex, and further adjustment for parental educational level, mode of commuting to school was not associated with overweight status (Table 4). Analyses with the categorical transportation variable revealed the same (Table III, Supplementary file).

Parents commuting to work

Table 3 shows the descriptive statistics for usual mode of commuting to work and its association with demographic variables. Table II in the Supplementary file, provides more detailed information.

Table 3 shows that in the total sample only 5.7% cycled on at least four days per week to work, while 18.6% walked , 44% for reported to use the car and 15% used public transport, and on at least 4 days per week (Table 3). The majority reported to never cycle to work (Table II, Supplementary file).

Demographics and commuting to work

Sex, their educational level, ethnicity and country were associated with mode of commuting to work (Table 3). Fathers less often walked (14.2 vs 19.1%), but more often took the car on at least four days per week to work (62.0% vs 39.8%) than mothers. Parents with lower levels of education less often cycled (3.6% vs 7.0%) or took the car (38.8% vs 46.6%) on at least four days per week, but more often walked (19.1% vs 16.9%) on at least four days per week to work compared to higher educated parents.

Parents with a non-native background more often walked (22.4% vs 17.9%) or took public transport (18.9% vs 11.8%) on at least four days per week to work, but less often cycled (3.3% vs 5.7%) or took the car (31.4% vs 44.5%) on four days per week compared to parents with a native background.

Greek parents least often cycled (0.4%), while Belgian (10.5%) and Dutch (18.3%) parents were most likely to bike to work frequently. However, Dutch and Belgian parents least often walked on four days per week to work (3.6% and 7.12% resp.), while this was most common among Greek parents (30.5%). Slovenian parents most often took the car on four days per week to work (76.3%), while this was least common among Dutch (21.4%) and Swiss (23.5%) parents. Dutch and Belgian parents least often used public transport on four days per week (4.5% and 9.0% resp.), while this was most common among Greek and Hungarian parents (27.7% and 24.5% resp.).

Overweight and commuting to work

Overweight parents cycled less often on at least four days per week, while they took the car or public transport on at least four days per week more often, compared to normal weight parents (Table 3). This is confirmed for cycling and car use in the crude analyses presented in Table 4. However, the difference for car use disappeared when adjusting for country, sex and parental education (Table 4). Yet, the association between cycling to work and overweight remained statistically significant after adjustment for country, sex and parental educational level (OR=0.74 (95%CI 0.57-0.97)). This was also confirmed in the analyses with the categorical variable for mode of transportation. Moreover, the effect estimates suggest a dose response relationship, with those who cycled most frequently having the lowest odds for being overweight (Table III, Supplementary file).

Discussion

The current study found differences in mode of commuting by demographic variables among both children and their parents which is in line with other studies. Walking but also public transport use was more common among children from parents with lower education while cycling and car use was more common among the higher educated. It may be that children from higher educated parents more often have parents who both have a paid job and drop their child at school while on their way to work by car. Another explanation may be that this observation was confounded by preferred ways of active transport in the different countries. For example, walking to school was most prevalent in Greece, a country with one of the highest prevalence rates of lower educated parents (48%). In other words, the observed association between walking and overweight may actually reflect the association between country and walking. That these associations are similar in children as in parents, may indicate that parents are important role models, or that other more cultural, environmental of safety factors may underlie these associations.

This study did not find significant associations between walking or cycling to school and weight status among children after adjusting for sex, country and parental educational level. Although the non-adjusted analyses indicated that cycling was inversely associated with overweight, this finding was most probably explained by country differences . In countries where cycling is most common (Norway and the Netherlands), overweight rates are among the lowest, 13.8% - 16.8% (Brug et al., 2012) . On the other side, cycling is very uncommon in Greece where overweight rates are the highest (44.4% in boys. 37.7% in girls). It is clear from the analyses that when country is added to the model, the associations disappear.

There are inconsistent findings in the literature between mode of commuting to school and overweight among children. In a systematic review of 39 studies assessing active travel to school and weight status or body composition, 14 studies found that active travellers had a more favourable body composition, while 3 studies reported the opposite and 22 did not find any differences between active and passive travellers (Larouche et al., 2014). As mentioned earlier, only very few studies looked at the specific association of cycling to school and body composition or cardiovascular fitness. One of these studies is a longitudinal study conducted among adolescents in Rotterdam and Kristiansand, and showed an inverse association between cycling and overweight (Bere et al., 2011). The inconsistencies found for the relation between cycling and overweight in children may be due to differences in methods and definitions, generally low frequencies of cycling to school in the populations, small sample sizes, or to differences between countries in cycling habits, distances et cetera (Bere & Andersen, 2009). Furthermore, it may take time to achieve health effects from active commuting, and children might be still too young to observe clear health effects from active commuting. In line with this, the present study does not support the hypothesis that cycling or walking to school may importantly contribute to prevention of overweight across Europe.

Contrary to the findings among children, among parents cycling to work was inversely associated with overweight, which is in line with two earlier Australian studies that reported that men cycling to work were significantly less likely to be overweight or had a lower BMI, compared to men using passive modes (Rissel, Greenaway, Bauman, & Wen, 2014; Wen & Rissel, 2008). That we found an association in adults but not in children, is in line with the hypothesis that long term exposure is needed. However, we have no data on how long these parents already use their bicycle to commute to work.

We did not find an association between walking to work and overweight. A review published in 2012 reported that 25 of the 30 included studies found an inverse association between active transport and body weight (Wanner, Gotschi, Martin-Diener, Kahlmeier, & Martin, 2012). All studies that did not find a significant association between active transport and body weight used self-reported data. Wanner and colleagues tried to summarize differential associations of cycling and walking with body weight (Wanner et al., 2012), but only one study analysed cycling and walking separately (Wen & Rissel, 2008) and four other studies used one single mode (Becker & Zimmerman-Stenzel, 2009; L. Frank, Kerr, Rosenberg, & King, 2010; L. D. Frank, Andresen, & Schmid, 2004; Titze, Stronegger, Janschitz, & Oja, 2008), and thus no clear pattern emerged.

A later review, published in 2013, included only longitudinal studies on active transport and health outcomes, but none of the included studies used weight status as an outcome (Saunders, Green, Petticrew, Steinbach, & Roberts, 2013). These two reviews illustrate the lack of evidence regarding potential differential associations with cycling and walking and regarding an aetiological association between active transport and weight status. More recently, cross-sectional studies confirmed that active travellers had lower risks for overweight (Berglund, Lytsy, & Westerling, 2016; Flint et al., 2014; Laverty, Palladino, Lee, & Millett, 2015; Lu, Su, Xiang, Zhang, & Wu, 2013; Millett et al., 2013), but only one of these studies differentiated between cycling and walking (Millett et al., 2013). That study was conducted in India and found that cyclist had lower odds than walkers for being overweight (Millett et al., 2013). In conclusion, our findings seem to be in line with earlier findings, but clearly more research is needed to assess causality and to separate out the effects of walking and cycling.

Strength and limitations

The limitations of the present study are the cross-sectional design, so that inverse causality –i.e. normal weight parents may be more inclined to take the bicycle to work-cannot be ruled out.

Furthermore, mode of commuting to school or work was self-reported as well as parental weight status, which may have been affected by recall and/or social desirability bias. Furthermore, distance to work or school was not included in the data, and may have additionally explained differences in mode of transportation as well as associations with weight status. In addition, mode of commuting may vary by season, especially in countries with great seasonal variances, such as Norway (Borrestad et al., 2011), and as such the children in Norway have probably reported their usual patterns in both seasons, which may have caused over-reporting (Brug et al., 2012). Lastly, we used BMI cut-offs to define overweight which has its limitations. BMI does not distinguish between body fat and lean mass. However, there is a broad consensus that BMI is a suitable index for adiposity, especially in epidemiological studies (U.S. Preventive Services Task Force, 2003; US Preventive Services Task Force & Barton, 2010). To define overweight we used the internationally accepted definitions and cut-offs provided by the IOTF. Although the cut-off values were carefully developed, it may still be arbitrary. It may be that children who actually have excessive fat mass, but had a BMI just below the cut-off were thus misclassified as having a normal weight and vice versa. Furthermore, using different definitions, such as the WHO or CDC definitions, may result in different prevalence rates (Brug et al., 2012; Rolland-Cachera, 2011)

The strength of the present study is the cross-European and large sample including both children and parents, the standardized measurements – including measures of weight and height among the children – and data handling, and the fact that we could distinguish between cycling and walking.

Conclusion

Mode of commuting varies by country and parental educational level and is not independently associated with weight status among 10-12 year old children in a cross-European sample. Among parents of 10-12 year olds, cycling for at least four days a week to work is associated with a lower risk for overweight, while other modes of commuting were not associated with weight status. Future interventions should take into account the socio-demographic differences in active transport and learn from countries were cycling or walking is common, like the Netherlands and Norway regarding cycling and Greece, Spain and Switzerland regarding walking. In the Netherlands, a developed infrastructure for cycling makes it an important transportation mode and also Norway has a well-developed infrastructure as well as a tradition or ‘culture’ for cycling, while there is a lack of proper bicycling infrastructure in Greece (Bassett, Pucher, Buehler, Thompson, & Crouter, 2008; Eliou, Galanis, & Proios, 2009; Fyhri & Hjorhol, 2006).

Table 1. Descriptive data of the included sample

	Total sample		Belgium		Greece		Hungary		The Netherlands		Norway		Slovenia		Spain		Switzerland	
Total (N)	7816		996		1085		1022		919		1000		1176		1022		596	
Sex (boys, N(%))	3792	48%	484	48%	506	46%	459	45%	474	49%	484	48%	579	49%	495	48%	311	52%
Age (years, mean + SD)	11.6	0.74	11.49	0.68	11.34	0.63	12.24	0.64	11.76	0.76	11.99	0.74	11.39	0.62	11.44	0.64	11.58	0.81
Age (min, max)	9.1	14.3	9.3	13.6	10.3	13.3	10.8	14.3	9.6	13.4	10.3	13.3	10.3	13.5	10.3	14.2	9.1	14.3
Ethnicity[1] (non-native, N (%))	617	8%	92	9%	108	10%	23	2%	75	8%	51	5%	95	8%	34	3%	139	23%
Parental education (≥ 14 years, N (%))	3719	65%	564	84%	461	52%	443	58%	274	77%	536	74%	509	56%	710	81%	222	40%
Weight status[2]																		
Overweight (N (%))	1413	18.3	121	12.1	328_b	30.3	200_c	19.6	107_a	12.1	126_a	12.9	242_c	21.2	219_c	21.8	70_a	11.6
Obese (N (%))	351	4.5	30	3.0	113	10.4	54	5.3	31	3.5	14	1.4	65	5.7	30	3.0	14	2.3
Total parents (N)	6349		741		977		913		389		835		998		942		554	
Sex (fathers, N(%))	1109	17.3%	93	12.5%	178	18.0%	133	14.5%	36	9.0%	171	20.4%	212	20.9%	183	19.2%	103	18.4%
Parental weight status[2]																		
Overweight (N (%))	1745	28.0%	182	25.5%	334	34.5%	230	25.5%	91	23.6%	237	29.2%	314	32.1%	240	26.1%	117	21.4%
Obese (N (%))	580	9.3%	60	8.4%	114	11.8%	120	13.3%	39	10.1%	71	8.7%	87	8.9%	54	5.9%	35	6.4%

Table 2. Descriptive statistics for **children's** mode of commuting by demographic variables and overweight status, assessed in 2010

	Cycling (≥ 4 days/week)			Walking (≥ 4 days/week)			Car (≥ 4 days/week)			Public Transport (≥ 4 days/week)		
	N	%	p-value[2]	N	%	p-value[2]	N	%	p-value[2]	N	%	p-value[2]
Total	1647	20.8		3833	48.4		1538	19.7		712	9.1	
Boy	847	22.7	0.002	1780	47.6	0.008	714	19.0	0.170	336	9.0	0.654
Girl	800	19.8		2053	50.6		824	20.3		376	9.2	
Normal weight	1348	23.0	< 0.001	2838	48.3	0.002	1139	19.3	0.127	522	8.9	0.142
Overweight[1]	251	14.3		919	52.3		369	21.0		176	10.0	
Lower educated (<14 years)	273	13.6	< 0.001	1106	55.3	< 0.001	320	16.0	< 0.001	280	14.0	< 0.001
Higher educated (≥14 years)	723	19.6		1817	49.2		892	24.1		226	6.1	
Non-native	116	19.0	0.145	353	57.3	< 0.001	81	13.1	< 0.001	62	10.0	0.393
Native	1528	21.4		3469	48.5		1450	20.2		647	9.0	
country [3]												
Belgium	294 [e]	29.7	< 0.001	203 [a]	20.5	< 0.001	395 [e]	39.7	< 0.001	59 [c]	5.9	< 0.001
Greece	10 [a,b]	0.9		812 [e]	74.9		177 [c]	16.3		33 [b, c]	3.0	
Hungary	36 [c]	3.6		379 [b]	37.1		310 [d]	30.3		299 [e]	29.3	
The Netherlands	548 [f]	59.8		246 [a]	26.9		43 [b]	4.7		6 [a]	0.7	
Norway	601 [f]	60.5		485 [c]	48.7		62 [b]	6.2		59 [c]	5.9	
Slovenia	34 [b, c]	2.9		538 [c]	46.0		353 [d]	30.0		196 [d]	16.7	
Spain	3 [a]	0.3		775 [e]	75.9		192 [c]	18.8		22 [a, b]	2.2	
Switzerland	121 [d]	20.4		395 [d]	66.5		6 [a]	1.0		38 [c]	6.4	

[1] including obese, according to IOTF cut offs; [2] tested by χ^2-test
[3] multi-group comparisons performed by Marascuilo's Post-hoc analysis, Each subscript letter denotes a subset of country categories whose proportions do not differ significantly from each other at the 0.05 level.

Table 3. Descriptive statistics for **parent's** mode of commuting to work by sex, weight status, educational level, ethnicity and country, assessed in 2010

	Cycling (≥ 4 days/week)			Walking (≥ 4 days/week)			Car (≥ 4 days/week)			Public Transport (≥ 4 days/week)		
	N	%	p-value[2]	N	%	p-value[2]	N	%	p-value[2]	N	%	p-value[2]
Total	356	5.7		1169	18.2		2798	43.6		786	12.2	
Mother	289	5.6	0.430	1012	19.5	< 0.001	2110	49.4	< 0.001	661	15.6	0.275
Father	67	6.1		157	14.4		688	66.3		125	12.2	
Normal weight	243	6.3	0.002	718	18.7	0.500	1647	51.1	0.001	456	14.3	0.069
Overweight[1]	101	4.4		412	18.1		1083	55.9		308	16.1	
Lower educated (< 14 years)	72	3,6	< 0.001	385	19.5	0.037	784	49.5	< 0.001	273	17.6	0.002
Higher educated (≥ 14 years)	260	7,1		627	17.1		1733	54.8		402	12.8	
Non-native	14	3.4	0.039	95	23.2	0.022	133	40.7	< 0.001	80	24.8	< 0.001
Native	337	5.8		1066	18.3		2644	53.5		702	14.4	
Country [3]												
Belgium	$77^{c,d}$	10.3	< 0.001	$53^{a,b}$	7.1	< 0.001	396_{a}	53.1	< 0.001	$57^{a,b,c}$	7.6	< 0.001
Greece	4^{a}	0.4		295^{e}	29.8		362_{b}	36.5		215^{d}	21.7	
Hungary	44^{b}	4.8		$222^{d,e}$	24.2		354_{b}	38.6		181^{d}	19.8	
The Netherlands	71^{d}	17.8		14^{a}	3.5		63_{c}	15.8		13^{a}	3.3	
Norway	43^{b}	5.1		114^{c}	13.6		$454_{a,e}$	54.0		$88^{b,c}$	10.5	
Slovenia	43^{b}	4.2		$121^{b,c}$	12.0		687_{d}	67.9		$57^{a,b}$	5.6	
Spain	35^{b}	3.7		256^{e}	26.8		$383_{b,e}$	40.1		112^{c}	11.7	
Switzerland	$39^{b,c}$	7.0		$94^{c,d}$	16.8		99_{c}	17.7		63^{c}	11.3	

[1] including obese, according to IOTF cut offs

[2] tested by χ^2-test

[3] multi-group comparisons performed by Marascuilo's. Each subscript letter denotes a subset of country categories whose proportions do not differ significantly from each other at the 0.05 level.

Table 4. Odds ratios for being overweight for children and parents by mode of commuting to school or work, assessed in 2010

	Crude model [1]			Model 1[2]			Model 2[3]			Model 3		
	OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI	
Children				n=7652-7655			n=5632-5633					
Cycling; (≥ 4 days/week vs < 4 days/week)	0.60	(0.52;	0.71)	0.98	(0.81;	1.18)	0.90	(0.70;	1.15)	0.85	(0.65;	1.10)
Walking; (≥ 4 days/week vs < 4 days/week)	1.12	(1.00;	1.26)	0.93	(0.82;	1.05)	0.89	(0.78;	1.03)	0.87	(0.72;	1.04)
Car; (≥ 4 days/week vs < 4 days/week)	1.08	(0.94;	1.24)	1.04	(0.90;	1.20)	1.10	(0.93;	1.29)	1.00	(0.82;	1.22)
Public Transport; (≥ 4 days/week vs < 4 days/week)	1.16	(0.96;	1.40)	1.09	(0.89;	1.32)	1.02	(0.81;	1.29)	0.97	(0.75;	1.24)
Parents				n=6195			n=5557			OR	95%CI	
Cycling; (≥ 4 days/week vs < 4 days/week)	0.71	(0.55	0.90)	0.70	(0.55;	0.91)	0.74	(0.57;	0.97)	0.76	(0.57;	1.00)
Walking; (≥ 4 days/week vs < 4 days/week)	0.96	(0.84	1.10)	0.99	(0.86;	1.14)	0.97	(0.83;	1.13)	0.96	(0.79;	1.17)
Car; (≥ 4 days/week vs < 4 days/week)	1.19	(1.06	1.33)	0.98	(0.86;	1.11)	1.04	(0.91;	1.19)	1.03	(0.87;	1.22)
Public Transport; (≥ 4 days/week vs < 4 days/week)	1.15	(0.99	1.35)	1.16	(0.95;	1.36)	1.10	(0.92;	1.32)	1.13	(0.92;	1.39)

[1] unadjusted, only for nested design (pupils nested in schools)
adjusted for nested design (pupils nested in schools) and for sex and country
[2] further adjusted for parental educational level
[3] further adjusted for the other modes of commuting
OR – odds ratio; CI – confidence interval
Note: n varies due to missing values on the co-variates

Acknowledgements

This paper was published on behalf of the ENERGY-consortium. The ENERGY-project is funded by the Seventh Framework Programme (CORDIS FP7) of the European Commission, HEALTH (FP7-HEALTH-2007-B), Grant agreement no. 223254. The content of this article reflects only the authors' views and the European Community is not liable for any use that may be made of the information contained therein.

References

Andegiorgish, A. K., Wang, J., Zhang, X., Liu, X., & Zhu, H. (2012). Prevalence of overweight, obesity, and associated risk factors among school children and adolescents in tianjin, china. *European Journal of Pediatrics, 171*(4), 697-703. doi:10.1007/s00431-011-1636-x [doi]

Andersen, L. B., Lawlor, D. A., Cooper, A. R., Froberg, K., & Anderssen, S. A. (2009). Physical fitness in relation to transport to school in adolescents: The danish youth and sports study. *Scandinavian Journal of Medicine & Science in Sports, 19*(3), 406-411. doi:10.1111/j.1600-0838.2008.00803.x [doi]

Andersen, L. B., Schnohr, P., Schroll, M., & Hein, H. O. (2000). All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. *Archives of Internal Medicine, 160*(11), 1621-1628.

Audrey, S., Procter, S., & Cooper, A. R. (2014). The contribution of walking to work to adult physical activity levels: A cross sectional study. *The International Journal of Behavioral Nutrition and Physical Activity, 11*(1), 37-5868-11-37. doi:10.1186/1479-5868-11-37 [doi]

Babey, S. H., Hastert, T. A., Huang, W., & Brown, E. R. (2009). Sociodemographic, family, and environmental factors associated with active commuting to school among US adolescents. *Journal of Public Health Policy, 30 Suppl 1*, S203-20. doi:10.1057/jphp.2008.61 [doi]

Bassett, D. R.,Jr, Pucher, J., Buehler, R., Thompson, D. L., & Crouter, S. E. (2008). Walking, cycling, and obesity rates in europe, north america, and australia. *Journal of Physical Activity & Health, 5*(6), 795-814.

Becker, S., & Zimmerman-Stenzel, M. (2009). Physical activity, obesity, and educational attainment in 50 - 70-year-old adult. *Journal of Public Health, 17*, 145. doi:10.1007/s10389-008-0222-9

Bere, E., & Andersen, L. B. (2009). Why no support for an association between active commuting to school and weight status in the literature? *Journal of Physical Activity & Health, 6*(5), 533-534.

Bere, E., Seiler, S., Eikemo, T. A., Oenema, A., & Brug, J. (2011). The association between cycling to school and being overweight in rotterdam (the netherlands) and kristiansand (norway). *Scandinavian Journal of Medicine & Science in Sports, 21*(1), 48-53. doi:10.1111/j.1600-0838.2009.01004.x [doi]

Bere, E., van der Horst, K., Oenema, A., Prins, R., & Brug, J. (2008). Socio-demographic factors as correlates of active commuting to school in rotterdam, the netherlands. *Preventive Medicine, 47*(4), 412-416. doi:10.1016/j.ypmed.2008.06.019 [doi]

Berglund, E., Lytsy, P., & Westerling, R. (2016). Active traveling and its associations with self-rated health, BMI and physical activity: A comparative study in the adult Swedish population. *International Journal of Environmental Research and Public Health, 13*(5), 10.3390/ijerph13050455. doi:10.3390/ijerph13050455 [doi]

Bopp, M., Kaczynski, A. T., & Campbell, M. E. (2013). Health-related factors associated with mode of travel to work. *Journal of Environmental and Public Health, 2013*, 242383. doi:10.1155/2013/242383 [doi]

Borrestad, L. A., Andersen, L. B., & Bere, E. (2011). Seasonal and socio-demographic determinants of school commuting. *Preventive Medicine, 52*(2), 133-135. doi:10.1016/j.ypmed.2010.12.006 [doi]

Brug, J., Te Velde, S. J., Chinapaw, M. J., Bere, E., De Bourdeaudhuij, I., Moore, H., . . . Singh, A. S. (2010). Evidence-based development of school-based and family-involved prevention of overweight across europe: The ENERGY-project's design and conceptual framework. *BMC Public Health [Computer File], 10*, 276.

Brug, J., van Stralen, M. M., Chinapaw, M. J., de Bourdeaudhuij, I., Lien, N., Bere, E., . . . te Velde, S. J. (2012). Differences in weight status and energy-balance related behaviours according to ethnic background among adolescents in seven countries in europe: The ENERGY-project. *Pediatr.Obes, 7*(5), 399-411.

Brug, J., van Stralen, M. M., Te Velde, S. J., Chinapaw, M. J., De Bourdeaudhuij, I., Lien, N., . . . Manios, Y. (2012). Differences in weight status and energy-balance related behaviors among schoolchildren across europe: The ENERGY-project. *PLoS One, 7*(4), e34742.

Chaix, B., Kestens, Y., Duncan, S., Merrien, C., Thierry, B., Pannier, B., . . . Meline, J. (2014). Active transportation and public transportation use to achieve physical activity recommendations? A combined GPS, accelerometer, and mobility survey study. *The International Journal of Behavioral Nutrition and Physical Activity, 11*, 124-014-0124-x. doi:10.1186/s12966-014-0124-x [doi]

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ (Clinical Research Ed.), 320*(7244), 1240-1243.

Cooper, A. R., Andersen, L. B., Wedderkopp, N., Page, A. S., & Froberg, K. (2005). Physical activity levels of children who walk, cycle, or are driven to school. *American Journal of Preventive Medicine, 29*(3), 179-184. doi:S0749-3797(05)00224-2 [pii]

Cooper, A. R., Wedderkopp, N., Jago, R., Kristensen, P. L., Moller, N. C., Froberg, K., . . . Andersen, L. B. (2008). Longitudinal associations of cycling to school with adolescent fitness. *Preventive Medicine, 47*(3), 324-328. doi:10.1016/j.ypmed.2008.06.009 [doi]

Cooper, A. R., Wedderkopp, N., Wang, H., Andersen, L. B., Froberg, K., & Page, A. S. (2006). Active travel to school and cardiovascular fitness in danish children and adolescents. *Medicine and Science in Sports and Exercise, 38*(10), 1724-1731. doi:10.1249/01.mss.0000229570.02037.1d [doi]

Davison, K. K., Werder, J. L., & Lawson, C. T. (2008). Children's active commuting to school: Current knowledge and future directions. *Preventing Chronic Disease, 5*(3), A100. doi:A100 [pii]

Duncan, S., Duncan, E. K., Fernandes, R. A., Buonani, C., Bastos, K. D., Segatto, A. F., . . . Freitas, I. F.,Jr. (2011). Modifiable risk factors for overweight and obesity in children and adolescents from sao paulo, brazil. *BMC Public Health, 11*, 585-2458-11-585. doi:10.1186/1471-2458-11-585 [doi]

Eliou, N., Galanis, A., & Proios, A. (2009). Evaluation of the bikeability of a greek city: Case study "city of volos". *WSEAS Transactions on Environment and Development, 5*, 545-555.

Evenson, K. R., Huston, S. L., McMillen, B. J., Bors, P., & Ward, D. S. (2003). Statewide prevalence and correlates of walking and bicycling to school. *Archives of Pediatrics & Adolescent Medicine, 157*(9), 887-892. doi:10.1001/archpedi.157.9.887 [doi]

Faulkner, G. E., Buliung, R. N., Flora, P. K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: A systematic review. *Preventive Medicine, 48*(1), 3-8. doi:10.1016/j.ypmed.2008.10.017 [doi]

Flint, E., Cummins, S., & Sacker, A. (2014). Associations between active commuting, body fat, and body mass index: Population based, cross sectional study in the united kingdom. *BMJ (Clinical Research Ed.), 349*, g4887. doi:10.1136/bmj.g4887 [doi]

Frank, L., Kerr, J., Rosenberg, D., & King, A. (2010). Healthy aging and where you live: Community design relationships with physical activity and body weight in older americans. *Journal of Physical Activity & Health, 7 Suppl 1*, S82-90.

Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine, 27*(2), 87-96. doi:10.1016/j.amepre.2004.04.011 [doi]

Fyhri, A., & Hjorhol, R. (2006). *Barns fysiske bomiljø, aktiviteter og daglige reiser [online].* (). Oslo: Transportøkonomisk institutt.

Herzig, M., Dossegger, A., Mader, U., Kriemler, S., Wunderlin, T., Grize, L., . . . Bringolf-Isler, B. (2012). Differences in weight status and energy-balance related behaviors among schoolchildren in german-speaking switzerland compared to seven countries in europe. *The International Journal of Behavioral Nutrition and Physical Activity, 9*, 139-5868-9-139. doi:10.1186/1479-5868-9-139 [doi]

Larouche, R., Saunders, T. J., Faulkner, G., Colley, R., & Tremblay, M. (2014). Associations between active school transport and physical activity, body composition, and cardiovascular fitness: A systematic review of 68 studies. *Journal of Physical Activity & Health, 11*(1), 206-227. doi:10.1123/jpah.2011-0345 [doi]

Laverty, A. A., Palladino, R., Lee, J. T., & Millett, C. (2015). Associations between active travel and weight, blood pressure and diabetes in six middle income countries: A cross-sectional study in older adults. *The International Journal of Behavioral Nutrition and Physical Activity, 12*, 65-015-0223-3. doi:10.1186/s12966-015-0223-3 [doi]

Lee, M. C., Orenstein, M. R., & Richardson, M. J. (2008). Systematic review of active commuting to school and childrens physical activity and weight. *Journal of Physical Activity & Health, 5*(6), 930-949.

Lindstrom, M. (2008). Means of transportation to work and overweight and obesity: A population-based study in southern sweden. *Preventive Medicine, 46*(1), 22-28. doi:S0091-7435(07)00305-2 [pii]

Lu, S. R., Su, J., Xiang, Q. Y., Zhang, F. Y., & Wu, M. (2013). Active transport and health outcomes: Findings from a population study in jiangsu, china. *Journal of Environmental and Public Health, 2013*, 624194. doi:10.1155/2013/624194 [doi]

Martinez-Gomez, D., Mielke, G. I., Menezes, A. M., Goncalves, H., Barros, F. C., & Hallal, P. C. (2014). Active commuting throughout adolescence and central fatness before adulthood: Prospective birth cohort study. *PloS One, 9*(5), e96634. doi:10.1371/journal.pone.0096634 [doi]

Millett, C., Agrawal, S., Sullivan, R., Vaz, M., Kurpad, A., Bharathi, A. V., . . . Indian Migration Study group. (2013). Associations between active travel to work and overweight, hypertension, and diabetes in india: A cross-sectional study. *PLoS Medicine, 10*(6), e1001459. doi:10.1371/journal.pmed.1001459 [doi]

Ostergaard, L., Borrestad, L. A., Tarp, J., & Andersen, L. B. (2012). Bicycling to school improves the cardiometabolic risk factor profile: A randomised controlled trial. *BMJ Open, 2*(6), 10.1136/bmjopen-2012-001307. Print 2012. doi:10.1136/bmjopen-2012-001307 [doi]

Ostergaard, L., Kolle, E., Steene-Johannessen, J., Anderssen, S. A., & Andersen, L. B. (2013). Cross sectional analysis of the association between mode of school transportation and physical fitness in children and adolescents. *The International Journal of Behavioral Nutrition and Physical Activity, 10*, 91-5868-10-91. doi:10.1186/1479-5868-10-91 [doi]

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: Lessons from the netherlands, denmark and germany. *Transport Reviews, 28*, 495-528.

Rissel, C., Greenaway, M., Bauman, A., & Wen, L. M. (2014). Active travel to work in new south wales 2005-2010, individual characteristics and association with body mass index. *Australian and New Zealand Journal of Public Health, 38*(1), 25-29. doi:10.1111/1753-6405.12097 [doi]

Rolland-Cachera, M. F. (2011). Childhood obesity: Current definitions and recommendations for their use. *International Journal of Pediatric Obesity : IJPO : An Official Journal of the International Association for the Study of Obesity, 6*(5-6), 325-331. doi:10.3109/17477166.2011.607458 [doi]

Saunders, L. E., Green, J. M., Petticrew, M. P., Steinbach, R., & Roberts, H. (2013). What are the health benefits of active travel? A systematic review of trials and cohort studies. *PloS One, 8*(8), e69912. doi:10.1371/journal.pone.0069912 [doi]

Shephard, R. J. (2008). Is active commuting the answer to population health? *Sports Medicine (Auckland, N.Z.), 38*(9), 751-758. doi:3894 [pii]

Singh, A. S., Chinapaw, M. J., Uijtdewilligen, L., Vik, F. N., van, L. W., Fernandez-Alvira, J. M., . . . Brug, J. (2012). Test-retest reliability and construct validity of the ENERGY-parent questionnaire on parenting practices, energy balance-related behaviours and their potential behavioural determinants: The ENERGY-project. *BMC Res.Notes, 5*, 434.

Singh, A. S., Mulder, C., Twisk, J. W., van Mechelen, W., & Chinapaw, M. J. (2008). Tracking of childhood overweight into adulthood: A systematic review of the literature. *Obesity Reviews : An Official Journal of the International Association for the Study of Obesity, 9*(5), 474-488. doi:10.1111/j.1467-789X.2008.00475.x [doi]

Statistical toolkit (StatsToDo). (2014). Retrieved from https://www.statstodo.com/multiprop_pgm.php

Taddei, C., Gnesotto, R., Forni, S., Bonaccorsi, G., Vannucci, A., & Garofalo, G. (2015). Cycling promotion and non-communicable disease prevention: Health impact assessment and economic evaluation of cycling to work or school in florence. *PloS One, 10*(4), e0125491. doi:10.1371/journal.pone.0125491 [doi]

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., . . . Crawford, D. (2006). Personal, family, social, and environmental correlates of active commuting to school. *American Journal of Preventive Medicine, 30*(1), 45-51. doi:S0749-3797(05)00364-8 [pii]

Titze, S., Stronegger, W. J., Janschitz, S., & Oja, P. (2008). Association of built-environment, social-environment and personal factors with bicycling as a mode of transportation among austrian city dwellers. *Preventive Medicine, 47*(3), 252-259. doi:10.1016/j.ypmed.2008.02.019 [doi]

U.S. Preventive Services Task Force. (2003). Screening for obesity in adults: Recommendations and rationale. *Annals of Internal Medicine, 139*(11), 930-932. doi:139/11/930 [pii]

US Preventive Services Task Force, & Barton, M. (2010). Screening for obesity in children and adolescents: US preventive services task force recommendation statement. *Pediatrics, 125*(2), 361-367. doi:10.1542/peds.2009-2037 [doi]

van Stralen, M. M., Te Velde, S. J., Singh, A. S., De Bourdeaudhuij, I., Martens, M. K., van der Sluis, M., Manios, Y., Grammatikaki, E., Chinapaw, M.J., Maes, L., Bere, E., Jensen, J., Jan, N., Molnar, D., Moore, H., Brug, J. (2011). EuropeaN energy balance research to prevent excessive weight gain among youth

(ENERGY) project: Design and methodology of the ENERGY cross-sectional survey. *BMC Public Health [Computer File], 11*, 65.

Voss, C., & Sandercock, G. (2010). Aerobic fitness and mode of travel to school in english schoolchildren. *Medicine and Science in Sports and Exercise, 42*(2), 281-287. doi:10.1249/MSS.0b013e3181b11bdc [doi]

Wanner, M., Gotschi, T., Martin-Diener, E., Kahlmeier, S., & Martin, B. W. (2012). Active transport, physical activity, and body weight in adults: A systematic review. *American Journal of Preventive Medicine, 42*(5), 493-502. doi:10.1016/j.amepre.2012.01.030 [doi]

Wen, L. M., & Rissel, C. (2008). Inverse associations between cycling to work, public transport, and overweight and obesity: Findings from a population based study in australia. *Preventive Medicine, 46*(1), 29-32. doi:S0091-7435(07)00371-4 [pii]

WHO, & FAO. (2003). *Diet, nutrition and the prevention of chronic diseases.* (No. 916). Geneva, Switzerland: World Health Organization.

Table I. Descriptive statistics for **children's** mode of commuting by demographic variables and overweight status, assessed in 2010

		Total	Boy	Girl	Normal weight	Overweight[1]	Lower educated (<14 years)	Higher educated (≥14 years)	Non-native	Native	Belgium	Greece	Hungary	The Netherlands	Norway	Slovenia	Spain	Switzerland
cycling to school (days/week)																		
0	N	5255	2439_{b}	2816_{a}	3813_{a}	1349_{b}	1551_{a}	2540_{b}	416_{a}	4822_{a}	469_{a}	1056_{b}	914_{c}	204_{d}	221_{d}	998_{e}	1004_{b}	389_{f}
	%	67.5	65.4	69.5	65.0	77.1	77.5	68.8	68.0	67.5	47.3	97.3	90.1	22.2	22.3	85.4	98.2	65.7
1 - 3	N	880	446_{a}	434_{a}	709_{a}	150_{b}	178_{a}	429_{b}	80_{a}	797_{a}	228_{a}	19_{b}	64_{c}	$165_{a, d}$	171_{d}	136_{e}	15_{b}	$82_{d, e}$
	%	11.3	12.0	10.7	12.1	8.6	8.9	11.6	13.1	11.2	23.0	1.8	6.3	18.0	17.2	11.6	1.5	13.9
≥ 4	N	1647	847_{b}	800_{a}	1348_{a}	251_{b}	273_{a}	723_{b}	116_{a}	1528_{a}	294_{a}	10_{b}	36_{c}	548_{d}	601_{d}	34_{c}	3_{b}	121_{e}
	%	21.2	22.7	19.8	23.0	14.3	13.6	19.6	19.0	21.4	29.7	0.9	3.6	59.8	60.5	2.9	0.3	20.4
	p-value[2]		<0.001		<0.001		<0.001		0.180		<0.001							
walking to school (days/week)																		
0	N	2792	1387_{b}	1414_{a}	2155_{a}	578_{b}	619_{a}	1336_{b}	175_{a}	2617_{b}	625_{a}	$163_{b, c}$	499_{d}	542_{a}	273_{e}	452_{f}	130_{c}	117_{b}
	%	35.9	37.1	34.9	36.7	32.9	30.9	36.2	28.4	36.6	63.0	15.0	48.8	59.2	27.4	38.6	12.7	19.7
1 - 3	N	1157	571_{a}	590_{a}	882_{a}	259_{a}	276_{a}	541_{a}	88_{a}	1069_{a}	164_{a}	109_{b}	$144_{a, b, c}$	$128_{a, b, c}$	238_{d}	$180_{a, c}$	$116_{b, c}$	$82_{a, b, c}$
	%	14.9	15.3	14.5	15.0	14.7	13.8	14.6	14.3	14.9	16.5	10.1	14.1	14.0	23.9	15.4	11.4	13.8
≥ 4	N	3822	1780_{b}	2053_{a}	2838_{a}	919_{b}	1106_{a}	1817_{b}	353_{a}	3469_{b}	203_{a}	812_{b}	379_{c}	246_{d}	485_{e}	538_{e}	775_{b}	395_{f}
	%	49.2	47.6	50.6	48.3	52.3	55.3	49.2	57.3	48.5	20.5	74.9	37.1	26.9	48.7	46.0	75.9	66.5
	p-value[2]		0.031		0.007		<0.001		<0.001		<0.001							
car to school (days/week)																		

0	N	4636	2277_{b}	2373_{a}	3546_{a}	1008_{b}	1258_{a}	2054_{b}	422_{a}	4214_{b}	371_{a}	721_{b}	482_{c}	743_{d}	653_{b}	$516_{a, c}$	628_{b}	536_{e}
	%	59.8	61.0	58.7	60.5	57.5	62.9	55.7	68.6	59.0	37.6	66.5	47.3	81.0	65.8	44.2	61.8	90.1
1 - 3	N	1587	742_{a}	848_{a}	1178_{a}	376_{a}	422_{a}	741_{a}	112_{a}	1475_{a}	$220_{a, b, c}$	$187_{c, d}$	$227_{a, b, c}$	131_{d}	277_{b}	299_{b}	$196_{a, c, d}$	53_{e}
	%	20.5	19.9	21.0	20.1	21.4	21.1	20.1	18.2	20.7	22.3	17.2	22.3	14.3	27.9	25.6	19.3	8.9
≥ 4	N	1531	714_{a}	824_{a}	1139_{a}	369_{a}	320_{a}	892_{b}	81_{a}	1450_{b}	395_{a}	177_{b}	310_{c}	43_{d}	62_{d}	353_{c}	192_{b}	6_{e}
	%	19.7	19.1	20.4	19.4	21.0	16.0	24.2	13.2	20.3	40.1	16.3	30.4	4.7	6.3	30.2	18.9	1.0
	p-value[2]		0.11		0.081		<0.001		<0.001		<0.001							
public transport to school (days/week)																		
0	N	6577	3168_{a}	3429_{a}	4985_{a}	1467_{a}	1588_{a}	3253_{b}	504_{a}	6073_{a}	$879_{a, b}$	$1003_{b, c}$	595_{d}	894_{e}	$876_{a, b}$	859_{f}	973_{c}	518_{a}
	%	85.0	85.0	85.0	85.3	83.7	79.6	88.4	82.4	85.2	89.2	92.4	58.4	98.2	88.6	73.7	95.7	87.4
1 - 3	N	452	224_{a}	229_{a}	339_{a}	109_{a}	127_{a}	201_{a}	46_{a}	406_{a}	47_{a}	$49_{a, b}$	124_{c}	10_{d}	54_{a}	$110_{c, e}$	$22_{b, d}$	$37_{a, e}$
	%	5.8	6.0	5.7	5.8	6.2	6.4	5.5	7.5	5.7	4.8	4.5	12.2	1.1	5.5	9.4	2.2	6.2
≥ 4	N	709	336_{a}	376_{a}	522_{a}	176_{a}	280_{a}	226_{b}	62_{a}	647_{a}	59_{a}	33_{b}	299_{c}	6_{d}	59_{a}	196_{e}	$22_{b, d}$	38_{a}
	%	9.2	9.0	9.3	8.9	10.0	14.0	6.1	10.1	9.1	6.0	3.0	29.4	0.7	6.0	16.8	2.2	6.4
	p-value[2]		0.754		0.271		<0.001		0.11		<0.001							

[1] including obese, according to IOTF cut offs; [2] tested by χ^2-test

[3] multi-group comparisons performed by Z-tests with Bonferroni correction. Each subscript letter denotes a subset of country categories whose proportions do not differ significantly from each other at the 0.05 level.

Table II Descriptive statistics for **parent's** mode of commuting to work by sex, weight status, educational level, ethnicity and country, assessed

		Total	Mother	Father	Normal weight	Overweight[1]	Lower educated (<14 years)	Higher educated (≥14 years)	Non-native	Native	Belgium	Greece	Hungary	The Netherlands	Norway	Slovenia	Spain	Switzerland
cycling to work (days/week)																		
0	N	5374	4448_a	926_a	3208_a	2017_b	1781_a	3013_b	381	4957	574_a	962_b	814_c	218_d	634_a	884_c	870_c	418_a
	%	85.4	85.5	84.6	83.8	88.2	90.1	82.3	91.8	85.0	78.3	99.3	89.6	56.3	76.7	89.5	93.1	76.0
1 - 3	N	566	464_a	102_a	378_a	170_b	123_a	388_b	20	537	82_a	3_b	$50_{c, d}$	98_e	$150_{e, f}$	61_d	29_c	$93_{a, f}$
	%	9.0	8.9	9.3	9.9	7.4	6.2	10.6	4.8	9.2	11.2	0.3	5.5	25.3	18.1	6.2	3.1	16.9
≥ 4	N	356	289_a	67_a	243_a	101_b	72_a	260_b	14	337	77_a	4_b	44_c	71_d	43_c	43_c	35_c	$39_{a, c}$
	%	5.7	5.6	6.1	6.3	4.4	3.6	7.1	3.4	5.8	10.5	0.4	4.8	18.3	5.2	4.4	3.7	7.1
	p-value[2]		0.684		<0.001		<0.001		0.001		<0.001							
walking to work (days/week)																		
0	N	4462	3636_a	826_b	2690_a	1653_a	1369_a	2665_b	265_a	4160_b	655_a	569_b	575_b	363_a	617_c	784_c	579_b	320_b
	%	70.9	69.9	75.6	70.2	72.5	69.4	72.8	64.6	71.3	89.0	58.8	63.3	93.8	74.8	79.6	61.8	58.3
1 - 3	N	664	554_a	110_a	426_a	216_b	219_a	370_a	50_a	609_a	28_a	104_b	111_b	10_a	94_b	80_b	102_b	135_c
	%	10.5	10.6	10.1	11.1	9.5	11.1	10.1	12.2	10.4	3.8	10.7	12.2	2.6	11.4	8.1	10.9	24.6
≥ 4	N	1169	1012_a	157_b	718_a	412_a	385_a	627_b	95_a	1066_b	53_a	295_b	222_b	14_a	114_c	121_c	256_b	94_c
	%	18.6	19.5	14.4	18.7	18.1	19.5	17.1	23.2	18.3	7.2	30.5	24.4	3.6	13.8	12.3	27.3	17.1
	p-value[2]		<0.001		0.079		0.025		0.014		<0.001							
car to work (days/week)																		

0	N	1685	1448_{a}	237_{b}	1046_{a}	578_{b}	556_{a}	927_{b}	150_{a}	1521_{b}	128_{a}	$351_{b, c}$	270_{d}	$132_{b, c, d}$	150_{a}	137_{a}	$298_{c, d}$	219_{b}
	%	31.7	33.9	22.8	32.5	29.8	35.1	29.3	45.9	30.8	20.2	44.4	36.3	44.9	19.5	15.2	39.1	52.0
1 - 3	N	830	717_{a}	113_{b}	527_{a}	278_{a}	244_{a}	504_{a}	44_{a}	781_{a}	$110_{a, b}$	78_{c}	$119_{b, d}$	99_{e}	$164_{a, b}$	76_{c}	$81_{c, d}$	$103_{a, e}$
	%	15.6	16.8	10.9	16.4	14.3	15.4	15.9	13.5	15.8	17.4	9.9	16.0	33.7	21.4	8.4	10.6	24.5
≥ 4	N	2798	2110_{a}	688_{b}	1647_{a}	1083_{b}	784_{a}	1733_{b}	133_{a}	2644_{b}	396_{a}	362_{b}	354_{b}	63_{c}	454_{a}	687_{d}	383_{b}	99_{c}
	%	52.7	49.4	66.3	51.1	55.9	49.5	54.8	40.7	53.5	62.5	45.8	47.6	21.4	59.1	76.3	50.3	23.5
	p-value [2]		<0.001		0.004		<0.001		<0.001		<0.001							
public transport to work (days/week)																		
0	N	3996	3174_{a}	822_{b}	2434_{a}	1455_{a}	1117_{a}	2471_{b}	194_{a}	3769_{b}	553_{a}	470_{b}	491_{b}	267_{a}	616_{c}	784_{a}	563_{c}	252_{b}
	%	76.1	75.1	80.4	76.3	76.2	71.9	78.8	60.1	77.1	87.2	60.5	66.5	91.8	80.7	88.5	75.0	61.5
1 - 3	N	468	392_{a}	76_{a}	299_{a}	147_{b}	163_{a}	262_{b}	49_{a}	416_{b}	24_{a}	92_{b}	$66_{b, c}$	$11_{a, c}$	$59_{a, b, c}$	$45_{a, c}$	76_{b}	95_{d}
	%	8.9	9.3	7.4	9.4	7.7	10.5	8.4	15.2	8.5	3.8	11.8	8.9	3.8	7.7	5.1	10.1	23.2
≥ 4	N	786	661_{a}	125_{b}	456_{a}	308_{a}	273_{a}	402_{b}	80_{a}	702_{b}	$57_{a, b, c}$	215_{d}	181_{d}	13_{c}	$88_{b, e}$	$57_{a, c}$	112_{e}	63_{e}
	%	15.0	15.6	12.2	14.3	16.1	17.6	12.8	24.8	14.4	9.0	27.7	24.5	4.5	11.5	6.4	14.9	15.4
	p-value [2]		0.002		0.038		<0.001		<0.001		<0.001							

[1] including obese, according to IOTF cut offs; [2] tested by χ^2-test
[3] multi-group comparisons performed by Marascuilo's Post-hoc analysis, Each subscript letter denotes a subset of country categories whose proportions do not differ significantly from each other at the 0.05 level

Table III. Odds ratios for being overweight for children and parents by mode of commuting to school or work, assessed in 2010

	Crude model [1]			Model 1[2]			Model 2[3]			Model 3[4]		
	OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI	
Children	n= 7598 - 7631			n= 7598 - 7631			n=5597-5517			n=5562		
Cycling; (0 days/week)	1			1			1			1		
Cycling; (1-3 days/week)	0.63	(0.52;	0.76)	0.91	(0.74;	1.12)	0.95	(0.74;	1.21)	0.93	(0.72;	1.19)
Cycling; (≥ 4 days/week)	0.56	(0.48;	0.66)	0.95	(0.78;	1.16)	0.88	(0.68;	1.14)	0.83	(0.62;	1.11)
walking (0 days/week)	1			1			1			1		
Walking (1-3 days/week)	1.08	(0.91;	1.28)	1.05	(0.89;	1.25)	0.97	(0.79;	1.19)	0.93	(0.74;	1.16)
Walking; (≥ 4 days/week)	1.15	(1.02;	1.30)	0.94	(0.83;	1.08)	0.88	(0.76;	1.03)	0.87	(0.69;	1.09)
Car (0 days/week)	1			1			1			1		
Car (1-3 days/week)	1.10	(0.96;	1.26)	1.13	(0.98;	1.30)	1.17	(0.99;	1.38)	1.14	(0.95;	1.36)
Car; (≥ 4 days/week)	1.11	(0.96;	1.28)	1.08	(0.93;	1.25)	1.15	(0.97;	1.36)	1.03	(0.81;	1.31)
Public Transport (0 days/week)	1			1			1			1		
Public Transport (1-3 days/week)	1.10	(0.88;	1.38)	1.04	(0.82;	1.31)	1.14	(0.87;	1.49)	1.03	(0.78;	1.36)
Public Transport; (≥ 4 days/week)	1.17	(0.97;	1.41)	1.09	(0.90;	1.33)	1.03	(0.82;	1.30)	0.96	(0.74;	1.25)
Parents	n= 5075 - 6086			n = 6086 - 5075			n = 6086 - 5075			n = 5005		
	OR	95%CI		OR	95%CI		OR	95%CI		OR	95%CI	
Cycling; (0 days/week)	1			1			1			1		
Cycling; (1-3 days/week)	0.73	(0.60;	0.88)	0.75	(0.61;	0.92)	0.76	(0.62;	0.93)	0.78	(0.62;	0.97)
Cycling; (≥ 4 days/week)	0.68	(0.54;	0.87)	0.67	(0.52;	0.87)	0.68	(0.53;	0.88)	0.66	(0.49;	0.87)
walking (0 days/week)	1			1			1			1		
Walking (1-3 days/week)	0.84	(0.71;	1.01)	0.88	(0.73;	1.05)	0.87	(0.72;	1.05)	0.90	(0.71;	1.12)
Walking; (≥ 4 days/week)	0.94	(0.82;	1.08)	0.97	(0.84;	1.13)	0.96	(0.83;	1.11)	0.86	(0.70;	1.06)

Car (0 days/week)	1			1			1			1		
Car (1-3 days/week)	0.95	(0.79;	1.13)	1.00	(0.83;	1.20)	1.00	(0.83;	1.21)	1.03	(0.84;	1.27)
Car; (≥ 4 days/week)	1.17	(1.02;	1.33)	0.98	(0.85;	1.13)	0.99	(0.86;	1.14)	0.88	(0.72;	1.08)
Public Transport (0 days/week)	1			1			1			1		
Public Transport (1-3 days/week)	0.83	(0.67;	1.02)	0.89	(0.71;	1.11)	0.89	(0.71;	1.11)	0.90	(0.70;	1.15)
Public Transport; (≥ 4 days/week)	1.14	(0.97;	1.33)	1.15	(0.97;	1.36)	1.14	(0.96;	1.35)	1.13	(0.93;	1.38)